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Recommender and Guidance Strategies for Creating Personal Mashup Learning Environments

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Abstract. This article presents an approach that supports the creation of personal learning environments (PLE) suitable for self-regulated learning (SRL). PLEs became very popular in recent years offering more personal freedom to learners than traditional learning environments. However, creating and configuring PLEs demand specific meta-skills that not all learners have. This situation leads to the challenge how learners can be supported to create PLEs that are useful to achieve their intended learning outcomes. The theory of SRL describes learners as self-regulated if they are capable of taking over control of the own learning process. Grounding on that theory, a model has been elaborated that offers guidance for the creation of PLEs containing tools for cognitive and meta-cognitive learning activities. The implementation of this approach has been done in the context of the ROLE infrastructure. A quantitative and qualitative evaluation with teachers describes advantages and ideas for improvement.

Keywords: self-regulated learning, personal learning environments, recommender, widget, widget store, mashup, ontology, learning activities

1. Introduction

In the recent years a trend became very popular to create small applications (also called tools or widgets) for specific purposes with limited functionalities. Online catalogues containing hundreds of thousands of such applications appeared for mobile and desktop area. Examples are the Google Play Store[6] or the Apple App Store[7]. Though they contain applications for learning purposes, most of them are general purpose applications. Due to this

[6] https://play.google.com/store/apps/
[7] http://itunes.apple.com/app/

huge amount finding applications for learning purposes in these catalogues becomes more and more difficult. A second trend became popular in the technology-enhanced learning area, systems and technology appeared that allow the creation of learning environments by mashing up such small applications. For example iGoogle[8] allows to choose from a large amount of widgets that can be included in the Google start page. Apache provides frameworks that allow to add widgets to a personal space (Shindig[9], Wookie[10]). Other approaches investigate the possibilities of mashup environments specifically for learning purposes, how environments can be created that support learning tasks.

Mashup environments are strongly related to Personal Learning Environments (PLE), if they are used for learning purposes. According to Henri et al. [16] PLEs refer to a set of learning tools, services, and artifacts gathered from various contexts to be used by the learners. A user requirements study revealed that PLEs are not seen as persistent environments, but they should evolve according to the learner's objectives and achievements [11]. Unlike traditional Learning Management Systems (LMS) where content and tools are predefined for the learner, PLEs are based on soft context boundaries with resources and tools being added at run time [28].

Though there are many efforts to create small applications and mashup technologies, there is still a lack of pedagogical support to create learning environments consisting of small applications. While some learners can create such environments on their own without any help, many learners need assistance and help on different levels [18]. Even teachers have difficulties with such a design, if they do not understand the role and benefit of self-created PLEs. As an underlying pedagogical model some authors (e.g. [11]) regard self-regulated learning (SRL) being a natural approach. However, SRL requires that users have specific skills (SRL skills) that allow them to take over control of their learning process. Therefore, guidance strategies are needed on a conceptual and technical level that supports both teachers and students in creating PLEs.

In our case an important goal of PLEs is the aspect that they should be suitable for self-regulated learning (SRL). Self-regulated learning is not just acquiring domain knowledge, but taking over control of the whole learning process and applying meta-cognitive strategies [31]. Though technology is not a requirement for that by nature, we consider a technical environment as particularly useful that supports these activities. Such an SRL-enabled environment should support learners in certain meta-cognitive activities, such as goal setting, self-evaluation, self-monitoring, or task strategies [4]. To this end, a PLE should contain widgets that are usable to perform these or similar cognitive and meta-cognitive learning activities. Therefore it is required that the widget space contains respective widgets.

This article presents an approach that addresses support on different levels between freedom and guidance to create and update own PLEs. In this way, the support can be adapted to learners with different SRL skills. While in literature SRL is usually described on a rather general level, this approach models SRL and related activities on a formal level. Using a template approach of SRL activities, learners can find appropriate tools for their own PLE meeting their needs. Two different implementations have been made following this model. First, a repository of learning tools (ROLE Widget Store) tags tools

[8] http://www.google.com/ig
[9] http://shindig.apache.org/
[10] http://wookie.apache.org/

with SRL activities and domain topics, which allows the users to browse the repository accordingly. Second, a recommender tool (Mashup Recommender) offers sets of SRL activities as templates, so that learners can find related tools for their PLEs.

The implementation has been done in the context of the ROLE project and its technical infrastructure. The European research project ROLE[11] aims to achieve progress beyond the state of the art in providing personal support for creating user-centric responsive and open learning environments. Learners should be empowered to create and use their own PLE consisting of different types of learning resources. Following these considerations, an infrastructure has been created in the ROLE project, which includes the two core components *Widget Store* and the *ROLE Platform* (also called ROLE SDK, because it is used to develop and establish learning resources). The Widget Store is Web-based software component that allows for managing catalogues of widgets and their metadata. The ROLE platform is a Web-based environment where widgets can be included and used together with other widgets. In the notation of ROLE a *space* is used to refer to a set of widgets that run on the ROLE platform. Additionally, such a widget space is capable of storing user information and application-specific data, in order to enable learning sessions over a longer time period. From a technical point of view, the ROLE platform allows for storing Contextual Attention Metadata (CAM) [25], which is a structured way of collecting log data. Moreover, widgets can exchange information with widgets in the same space or even in other spaces.

This technology addresses both teachers and learners as users. Teachers or tutors can create widget spaces and share them with their students, but also students or learners in general can create widget space on their own. Usually learning is done towards a goal which defines what should be learned. Examples of such goals are attaining knowledge in certain topics of chemistry or mathematics, acquiring reading or speaking abilities in foreign languages, or becoming able to solve problems collaboratively. In order to address such goals, widgets are selected that support learning toward these goals. Having the examples above in mind, it becomes clear that learning is done in different ways. For instance, acquiring domain knowledge needs different learning methods than training to speak English. When focusing on the learning methods, the widgets come into play. Considering that different methods are applied for achieving a goal, it's obvious that different widgets would be applied. Fig. 1 shows an example for training to speak English. Different widgets are available to perform different learning tasks, for example, a text-to-speech widgets help with pronunciation, a video conferencing widget can be used to talk to a tutor or native speaker, or a spell-check widget helps with correct writing [24].

The remainder of this article is structured as follows: Related work mainly on PLEs is described in Section 2. The theoretical background on SRL and how it is related to PLEs is explained in Section 3. In order to move the theory towards technology, Section 4 describes the operationalisation of SRL in terms of an ontology. The first type of guidance strategy is integrated in the Widget Store, which is described in Section 5. The second type of guidance strategy is established by developing the Mashup Recommender (see Section 6). The technical perspective regarding system architecture and implementation is discussed in Section 7. Finally, Section 8 reports on evaluation results demonstrating the usefulness of this approach.

[11] http://www.role-project.eu/

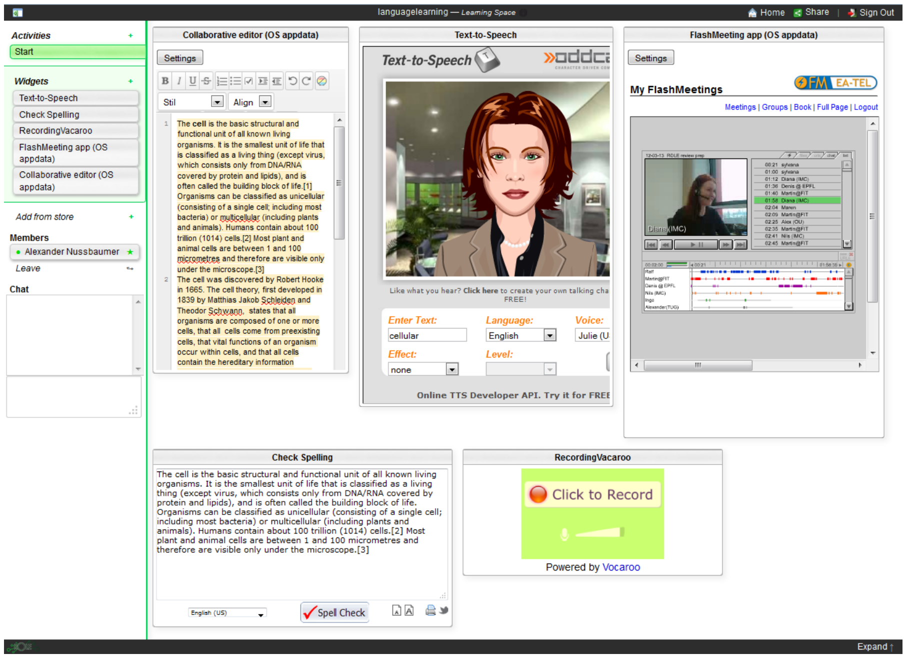

Fig. 1. ROLE Space for a language learning scenario. Various learning tasks can be performed with different widgets, including a collaborative writing widget, a text-to-speech widget, a video conferencing widget, a spell checker widget, and a audio recording widget.

2. Related Work

Traditionally, technology for learning support was centred on Learning Management Systems (LMS). They primarily focus on distributing learning content, organising the learning processes, and serving as interface between learner and teacher. In educational institutions LMSs have become very popular and are used in many universities and schools [22]. Examples of LMSs are Moodle, CLIX, Blackboard, WebCT, Sakai, ILIAS and .LRN. They all have in common, that different tools are integrated in a single system, such as discussion forums, file sharing, whiteboards, chat, and e-portfolios [6]. These tools together with learning content are bundled by teachers or tutors, which leads to a centralised and standardised learning experience [14].

In contrast to an LMS, a Personal Learning Environment (PLE) strives for a more natural and learner-centric approach and is characterised by the freedom that individual learners have to select and control services and tools they use. In recent years, attempts have been made to build PLEs based on mash-up designs. An example based on social media tools is eMUSE [23], which integrates Web 2.0 tools into a single system. It claims that such tool integration leads to a sense of community and thus increases success and retention rates. Furthermore, eMUSE offers support for self-monitoring and self-evaluation by providing feedback on learning tasks, which is supposed to increase learning success and motivation. A shortcoming of eMUSE is that it allows instructors to create such settings of tools and does not give learners the freedom of selecting tools and personalising their environment.

A further example is the PLE developed at the Graz University of Technology [8]. This PLE allows for selecting widgets from a repository and adding them to a personal space. Beside some general purpose widgets (similar to the tools in an LMS), domain-specific widgets have been created by students in university courses. It also allows for logging students' activities performed on these PLEs. A drawback of this PLE is the missing pedagogical support for selecting widgets. In the course of a study [26], a semantic model has been created to analyse the activities and display them on a dashboard. This study revealed that the teacher is no longer the provider of knowledge, but rather a mediator between knowledge and student. On the other side, the student is responsible for organising information and own learning.

The Graasp system [3] allows users to create their own PLEs consisting of people, spaces, assets, and tools. In addition, it also provides an activity model to describe the learning tasks. One of the aims is the support for sharing resources among learners, for example they can share the tools and assets they use. Graasp also offers a repository of widgets (or tools) that can be added to the personal environment. Moreover, Graasp provides an infrastructure for the creation of recommendation strategies through an interface for retrieving learner data.

Another approach is the augmentation of traditional LMSs with widgets, in order to make an LMS more flexible. Such an implementation is described in [29], where Moodle has been modified to support the integration of widgets from a repository. The difficulty with this approach is the lack of communication between Moodle and the widgets. So the integration is done only on the level of the user interface, but not on the level of learner information integration.

On a theoretical level a general approach is described in [27]. The authors call this approach a mash-up personal learning environment (MUPPLE) and regard it as a vision of the future of personalised, networked, and collaborative learning. One of the statement is that a learning environment is not only created on a technical level, but it consists of a network of people, artifacts and tools centred around learning activities that are performed towards a previously defined learning outcome. This approach is also demonstrated with a prototypical implementation and a concrete scenario.

In order to provide specific support for learners, there are some approaches and implementations of recommendation strategies available. ReMashed [7], a system that follows the MUPPLE design, provides recommendation of Web 2.0 resources. Learners can personalise emerging information of a community can rate information of the Web2.0 sources. Based on this user-generated information and collaborative filtering mechanisms, ReMashed offers tailored recommendation to the learner. A similar approach done by the Binocs widget [12] that uses a federated search engine in the background and makes recommendations for learning resources (learning objects) based on social tagging.

A different recommendation approach is described in [17]. In contrast to providing learning resources on content level, this approach is based on a model that recommends learning activities based on a taxonomy of cognitive and meta-cognitive learning activities. The learner selects recommended activities and based on these choices new recommendations are generated. This approach is supposed as help for especially weak learners to guide them through the learning process. A more complex approach is the 3A model [9], that provides recommendations based on actors (users or agents), (individual or collaborative) activities, and assets (Web resources) in a PLE. Collaborative filtering and page rank strategies are used to recommend these entities.

The major contribution of this article is a tool recommender and guidance strategy that supports the learner in creating the whole personal environment. While the aforementioned PLE systems give the control more or less completely to the learner, our approach supports the creation by offering different granularity levels of guidance. In contrast to the recommendation strategies listed above that mainly focus on content-based resources or activities, we put emphasis on the recommendation of tools.

3. Self-regulated Learning and Personal Learning Environments

According to Zimmerman [31] students can be described as self-regulated to the degree that they are meta-cognitively, motivationally, and behaviourally active participants in their own learning process. To define students' learning as self-regulated, the learners have to use specific strategies for attaining their goals and all this has to be based on self-efficacy perceptions. In this context there are three elements which are important, namely the self-regulated learning strategies of students, their perceptions of self-efficacy regarding to their performance skills, and their commitment to academic goals. Several models for self-regulated learning have been defined, for example a cyclic model by Zimmerman [30] or a layered model by Boekaerts [2]. They have in common some fundamental assumptions: The learners are active and are able to control, monitor and regulate their cognition, motivational state, behaviour and context. Furthermore, the learners set goals, tries to achieve them through progress-monitoring and adaption of cognition, motivation, behaviour and context (learning process). These self-regulatory activities are mediators between personal characteristics, contextual features, and actual performance in the learning process. In a meta-analysis conducted by Hattie [15] it turned out that performing self-regulatory activities in the learning process is one of the most effective methods to reach the learning goals.

A model for SRL in the context of PLEs has been proposed in [10]. This approach is based on a modified version of the cyclic model for SRL as proposed by Zimmerman [31]. It states that SRL consists of four cognitive and meta-cognitive phases (or aspects) that should happen during the self-controlled learning process, which are planning the learning process, search for resources, actual learning, and reflecting about the learning process. In addition to these phases and in order to operationalise them, a taxonomy of learning strategies and learning techniques (see Section 4) has been defined and assigned to the learning phases (see Fig. 2). Following the ideas presented by Mandl [19], learning strategies and techniques are related to the cyclic phases in order to define explicit activities related to SRL. SRL strategies describe the conceptual background, when self-regulatory activities are applied. More precisely, learners apply learning techniques (such as brain storming, goal setting, or note taking) which are categorised according to learning strategies.

Self-regulated learning is therefore a hard task for the learner. It requires that she is able to use her autonomy in order to ask the right questions that she wants to get answered, to find out what she has to learn and how she should do that and to reflect her own activities

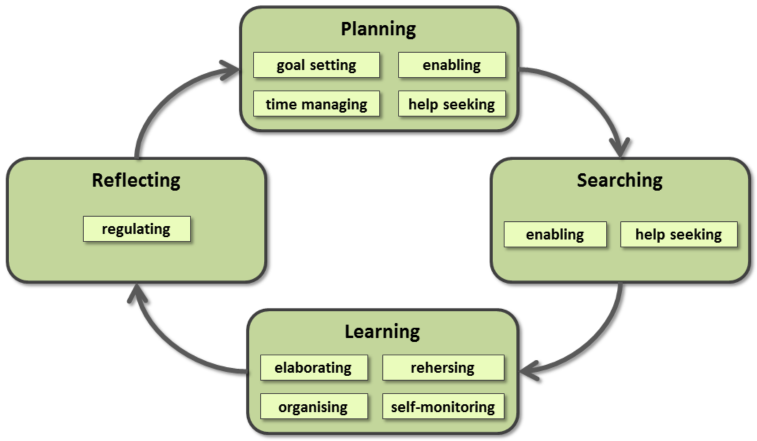

Fig. 2. Diagram of self-regulated learning process model and assigned SRL strategies.

in order to adjust her behaviour. However, one has to note that self-regulatedness is not a binary feature. It can come in various degrees, and most self-regulated learners will have to ask for help some time or temporally give up their autonomy and follow the guidance of a teacher. Different levels of self-regulatedness require different kinds of support. While a total novice will first need an introduction into the concept of SRL and its core techniques, an experienced self-regulated learner might just ask for some hints on appropriate contents and tools.

In order to introduce the concept of SRL to learners and to motivate them for SRL, a teaser video and an online course have been designed and tried out with learners in academia and economy [21][20]. The goal of this approach was to give novice learners an entry into self-regulated learning with PLEs. Moreover, the prototype of a layered PLE with layers for each phase defined in the SRL model has been implemented and successfully tested [5]. This prototype was implemented as a Personal Learning Management System (PLMS) consisting of pages with widgets. The layered PLE also overcomes the problem of cluttered PLEs with too many widget in one space.

It is also important to realise that SRL is a challenge not only for the learner but also for the teacher who has to support learners who do not just follow her guidance but use their autonomy for following their own preferences and implementing their own learning style. One means of supporting a SR learner is to pre-define an initial PLE or a template for such a PLE that the learner can adjust later according to her own preferences. From the perspective of a teacher a PLE is not only a learning environment but also a teaching environment. A recommender as described in this paper therefore needs not only be a tool for immediately supporting learners, it can also be used by teacher to get recommendation on how to support SR learners or, in other words, on how to compile a PLE as a well-suited teaching environment.

The basic assumption of creating good PLEs is that the assembly of widgets to a widget bundle should follow a pedagogical approach based on self-regulated learning. While widget containers typically allow for compiling PLEs in a completely free way, our approach suggests that the creation of widget bundles should follow a pedagogical approach that is based on underlying educational constructs related to widgets. Assembling widgets in a PLE then follows some guidelines which underlying constructs should be contained and how they should be assembled [1]. One of these guidelines is that widgets should be available that are used to perform more than one SRL strategy. For example, a learner should not only read a text, but also should be aware what the goal of the learning process is, discuss the topic with peers, and self-evaluate her progress.

Therefore, the assembly of widgets should reflect the underlying learning strategies and techniques. In contrast to existing approaches where just widgets are compiled to a bundle, our approach proposes to start with the consideration which SRL strategies should be supported by the PLE. In a second step widgets should be found for the selected SRL strategies and added to the widget space. Because of the relations between SRL strategies and widgets, widgets can be recommended for a PLE. If a widget is tagged with more than one SRL strategy, the ones with fewer and exact matching strategies are ranked better. In contrast to collaborative recommendation approaches that are based on social usage data to generate recommendations, this approach is based on a pre-defined ontology. The advantage of this approach lies in the fact that the learner's attention can be drawn to meta-cognitive aspects of learning even if other learners do not follow these aspects.

4. Operationalisation of Self-Regulated Learning

Though a lot of literature, theoretical considerations, and conceptual models are available, there are almost no approaches describing how to operationalise them and use them for concrete technological support. This section describes our model of the operationalisation of self-regulated learning on a conceptual and technical level.

4.1. Basic Concepts

The origin of this operationalisation model is the work done by Zimmerman [31] on SRL phases, Dabbagh & Kitsantas [4] on SRL processes, and Mandl & Friedrich [19] on SRL strategies and techniques. These findings have been adapted and integrated, in order to serve as a comprehensive and integrated model for technology-support. The SRL phases model of Zimmerman has been extended by the new phase *search* which addresses the search for Web resources and creation of PLEs. The SRL processes described by Dabbagh & Kitsantas have been used as a basis for the definition of the SRL strategies and extended with strategies specifically needed for the compilation of PLEs. The model of strategies and techniques of Mandl & and Friedrich has been used as a basis for the relation of SRL processes and techniques applied when using tools and widgets. The overall model is depicted in Fig. 3.

Using this theoretical background, have defined nine SRL strategies and structured them in three groups, which are cognitive strategies, meta-cognitive strategies, and resource management. The group of cognitive strategies includes organisation, elaboration, and rehearsal tasks of learning topics. The group of meta-cognitive strategies include goal setting, self-monitoring, regulation tasks targeting the control of the own learning process. The group of resource management strategies include time management, help-seeking, and enabling (or environment preparation) describing that learners take care for

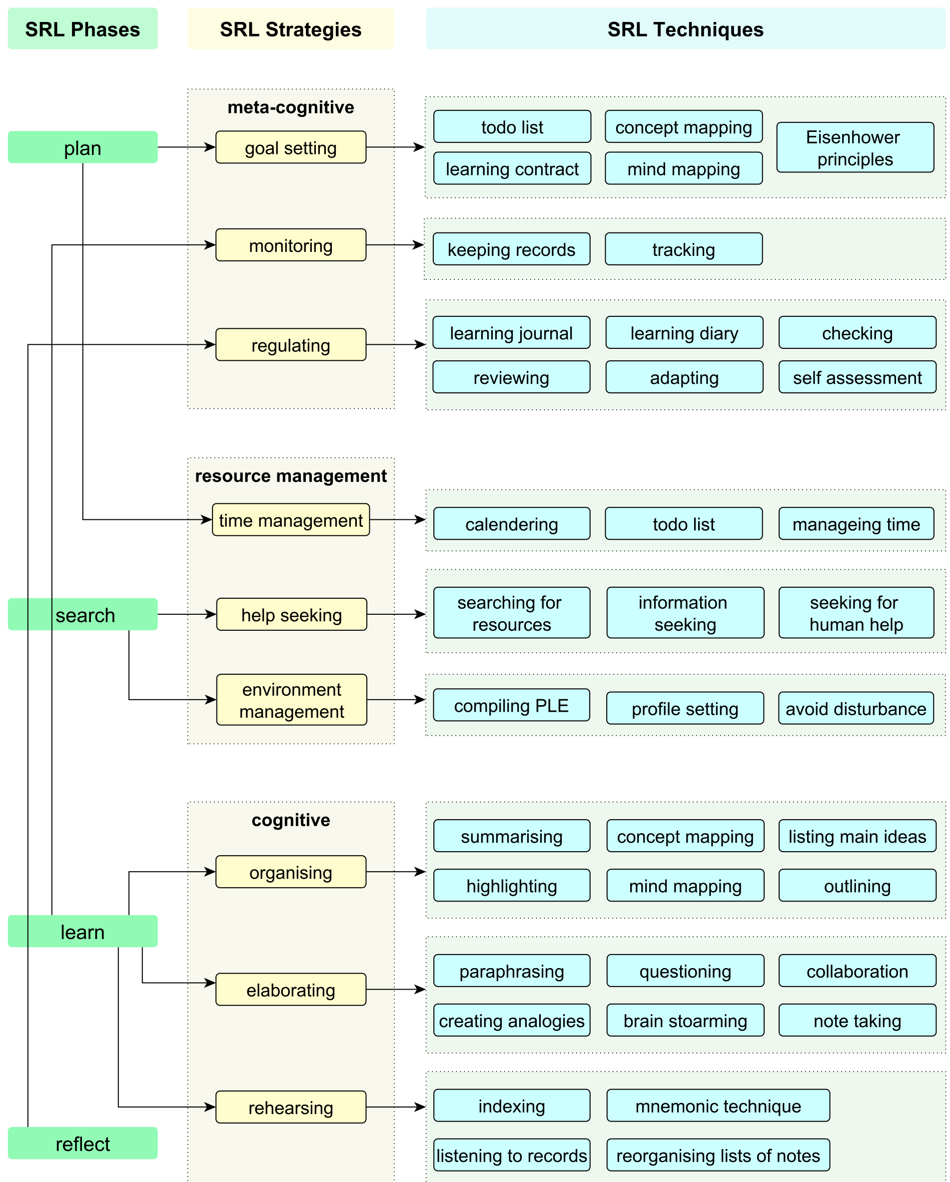

Fig. 3. Diagram of the SRL ontology that includes and connects the instances of the SRL phase, SRL strategy, and SRL technique elements. The arrows indicate that (1) a SRL phase includes specific SRL strategies and (2) a SRL strategy is adopted by applying a specific SRL technique from the referenced rectangle.

their learning resources. These strategies are connected SRL phases, which enriches the meaning of these phases with a clearer notion.

For each of the nine listed learning strategies a variable number of learning techniques are assigned. For instance, the *elaboration* strategy can be adopted by applying the learning techniques *paraphrasing*, *creating analogies*, *producing questions*, *note-taking*, *brainstorming*, and *collaborative learning*. Literature often provides no clear distinction between learning strategies and learning techniques (e.g. [19]). Learning strategy is rather an umbrella term to classify learning techniques and various authors provide different presentations how they relate to each other. Learning techniques in turn often are defined to be sophisticated methods to implement learning activities. Learning strategies can be understood as the *what* (what do I want (or have) to do?) and learning techniques as the *how* (how do I perform the learning activity). Learning techniques can be related to multiple SRL strategies, for example *concept mapping* can be applied to adopt the cognitive strategy *organising*, as well as the meta-cognitive strategy *goal setting*. The strategies are listed in Fig. 3.

Another important aspect is the connection between the pedagogical constructs (learning strategies and techniques) and the widgets. Instead of direct assignment the pedagogical constructs to widgets, widget functionalities are used as mediator construct. A functionality assigned to each widget describes the purpose of a widget for which it is designed and its capability to fulfil specific functions. A set of functionalities have been designed and related to learning techniques. While the learning techniques describe how learning takes place, the assigned tools functionalities describe what technical instruments can be applied. This mediator approach has the advantage that widget creators do not have to take care for the pedagogical purpose, but just have to describe what can be done with that widget. On the other side, pedagogical experts can make the assignment of learning techniques with functionalities without knowing which widgets are available.

4.2. Ontology

In order to establish structural information regarding the learning phases, strategies, techniques, and widget functionalities in a technical sense, an ontology has been created that contains these constructs. On top there are learning phase and each learning phase is related to learning strategies. The learning strategies are related to learning techniques, which in turn are related to widget functionalities. The relation to tool functionalities is important, because they are the connection to the widgets in the widget store, where widgets are related to the same tool functionalities. The ontology is modelled in RDF format, in order to be used by technology.

5. Widget Store

5.1. Conceptual Approach

The ROLE Widget Store is a Web-based online catalogue that allows to manage and index widgets. It provides a user friendly interface to a widget repository that simplifies the discovery of widgets. The functionality of the widget store includes listings of widgets, categorisations, search by widgets by keywords and compile widgets into bundles.

A screenshot of the user interface displaying a search result is shown in Fig. 4. Users can add widgets from a widget store to PLE systems. From a social media point of view, the store is also the place to collect and share user tags, comments and ratings. A widget creator and developer can add a widget to the store by adding its reference (URL) and metadata.

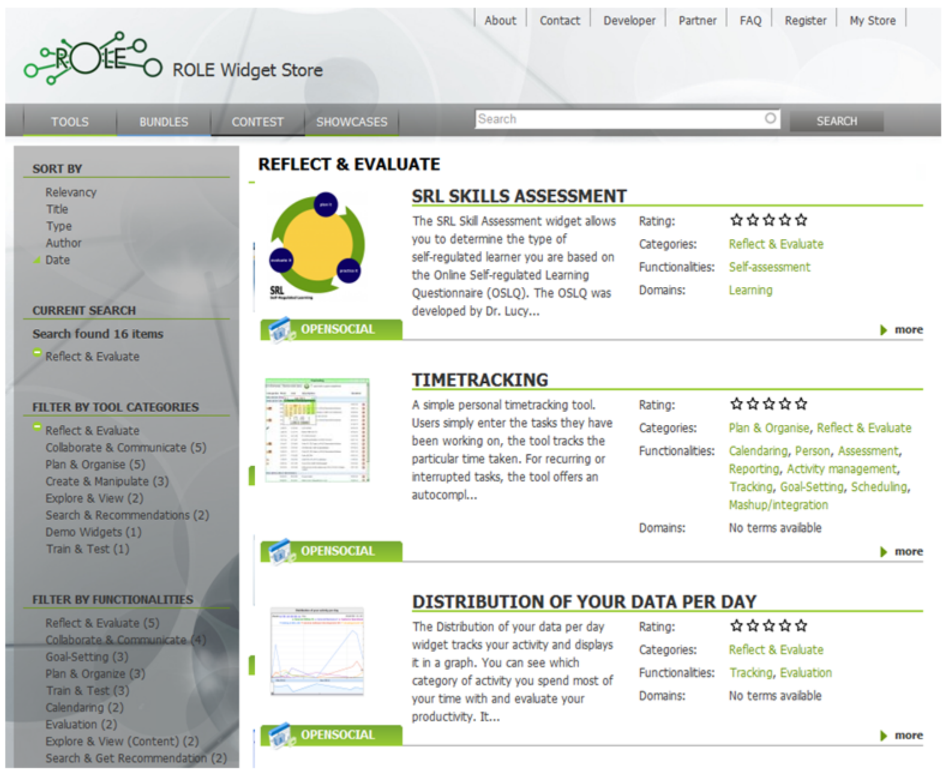

Fig. 4. Screenshot of the Web interface of the Widget Store. The result of a search for widgets with the category *Reflect & Evaluation* is shown.

The term widget is used for small independent programs displayed in a Web page. A widget container is needed to render and execute a widget. Some Widgets are able to communicate via the widget engine with the widget container on which the widgets are running. For the developing of widgets often web technologies like DHTML, JavaScript, Flash and Ajax are used. In many cases widgets consist of both the user interface and a back-end service. This approach allows for having simple and small user interfaces with complex functionality in the background. For example, a widget that searches for learning content in a federated search engine consists of search field and result list in the user interface and a powerful and complex search engine in the back-end.

An important feature of the Widget Store is its openness for other systems and technical components. It provides an interface to the repository of widgets and metadata, so that other systems can perform search activities on the repository and retrieve information in structured way. To this end, the Widget Store allows for semantic search (SPARQL) and delivers results in machine readable format (XML). There are no specific requirements for widgets to be added to the Widget Store, except that they comply with the OpenSocial or the W3C standard. Additionally, widgets are tagged with pedagogically notations, which aims at having widgets for learning purposes only in the store.

5.2. Guidance Strategy

In order to provide guidance for learners in searching and selecting widgets for their PLEs, widgets can be tagged with metadata describing the purpose of the widgets. The first type of tags is a widget categorisation consisting of seven categories. The categories were derived from the SRL learning phase model (see Section 3) and are assigned to its phases (see Fig. 5). As described above a PLE should consist of widgets not only for one learning strategy, but widgets for different strategies should be included. The categorisation system is a useful way to follow this guideline, because users get quick access to widgets for the specific purposes. They can browse the store and add widgets just by navigating to different categories.

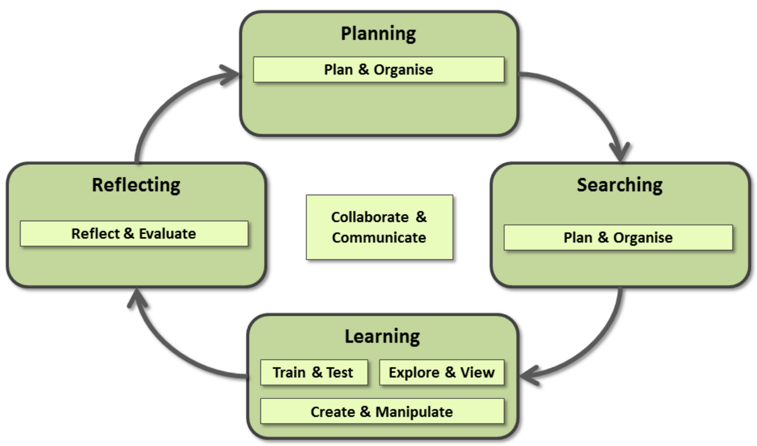

Fig. 5. Widget Store Categorisation. Seven categories and their relation to the phases of the self-regulated learning model are depicted. The category in the centre is assigned to all phases.

In addition to the widget categories, functionalities described in an ontology (see Section 4) are used to represent features of widgets (e.g. text editing, video chat). These functionalities are derived from a survey of existing widgets and from an analysis of the ontology. The SRL techniques are related to functionalities so that the ontology and the Widget Store share the same set of functionalities.

The third type of metadata is the domain concept describing widgets regarding a knowledge domain they are related to. Widgets can be either generic (e.g. text editor) or targeting specific learning domains (e.g. French language). As these widgets can be hardly described by tool categories or functionalities, therefore a categorisation based on learning domains is introduced. The service of DBpedia[12] is used to allow users tagging widgets by semantically unique learning domains supporting them in search for specific tools.

The user interface of the Widget Store allows for searching and filtering widgets according categories, functionalities, and domain concepts. A list of widgets is listed according to the applied search. Additional filters can be applied regarding the metadata available for the listed widgets. The metadata for each widget is shown in the search result list, which is category, functionalities, domain concepts, rating, title, and description.

Additionally, the Widget Store also services as a back-end service for other recommender tools that offer guidance to the users (see Section 6). Using the metadata information of the widgets (category, functionality, domain concept), other recommenders can detail their search for widgets and use the result for their own guidance strategy.

6. Mashup Recommender

6.1. Conceptual Approach

The aim and purpose of the Mashup Recommender is to recommend widgets for the personal widget space according to a template of SRL activities. The template is a set of SRL phases, strategies, and techniques from the ontology described in Section 4. Entities from this ontology can be added in a random sequence and by varying the type of the entity. This recommender is implemented as a widget and is part of the widget space which it recommends widgets for. It accesses the repository of the Widget Store for generating recommendations. When the user clicks on an entity of the template, a set of widgets is recommended from which the user can choose. This recommendation is created by using the ontology where entities are related to tool functionalities that are also used in the Widget Store. A simple click on a recommended widget adds this widget to the current space. A screenshot of a widget space is shown in Fig. 6. In this screenshot the the Mashup Recommender is shown together with one recommended widgets. Typically, the widget space is populated with multiple widgets, at least one widget for each SRL activity from the template should be included. A possible problem of this approach occurs, if the space is be overloaded with widgets. However, it is the decision of the learner, how many widgets she wants to have in the own space. A solution to the problem is that more spaces can be created and the learner switches between these spaces (similar to virtual desktops).

6.2. Guidance Strategy

The Mashup Recommender can be used to provide guidance on different levels and for different stakeholders. A high level of guidance is the preparation of complete predefined PLEs based on a specific template by a teacher or tutor. Then the tutor can share this PLE with her students who can use it and also modify it. A lower level of guidance can be provided if the teacher just shares the template with the students, so that they have to create their own PLE. For example, a teacher could select the SRL entities *goal setting*,

[12] http://dbpedia.org/

Fig. 6. Mashup Recommender widget and ROLE platform. This diagram shows a widget space with the Mashup Recommender and a widget that has been recommended and included.

resource searching, *note taking*, *debating*, and *reflecting* for a template. Then teachers or learners using this template could easily search for widgets for each of these SRL entities and include them in a PLE. In this way the PLE consists of widgets for each SRL entity.

Templates can also be made that mainly relate to cognitive activities. Such activities mainly relate to widgets focusing on domain-specific topics. In this way a PLE is created that does not explicitly support SRL way of learning. The example in Section 1 (Fig. 1) focusing on language learning is such a PLE that can be expressed as a template as well.

It makes a difference if SRL phases, SRL strategies, or SRL techniques are included in a template. Learning strategies are on a higher abstraction level, which results in a greater number of widgets that can be recommended. Learning techniques are on a lower abstraction level, which leads to a smaller number of related widgets that can be recommended. While in the first case the learner gets more widgets recommended and thus less guidance, in the second case the level of guidance is higher because of the smaller number of recommended widgets. In the case of hard-wired assignment of widgets to freely defined learning activities the level of guidance can also freely be set. In case of using the Widget Store tool categories, the level of guidance is rather small, because all available widgets are assigned to seven template elements.

The creation of the templates is typically done by a teacher or tutor, not by learners themselves. In this way, the teacher provides the guidance for the learners, which opens up the possibility for the teachers to adjust the guidance to the actual curriculum and to the group of learners. This approach leads to a specific form of SRL, where a teacher still provides scaffolding. The reason for the approach arose in the testbeds where teachers wanted to provide predefined learning environments and learners had problems to create their own learning environments. Instead of letting the control fully by the teacher, this approach still encourages SRL by stimulating learners to find their widgets in a guidance context. Learners become aware about the SRL activities they should perform with the selected widgets and that the created PLE should be used in a SRL way of learning.

The highest level of freedom is the creation of templates by learners themselves. Since learners have to choose from a list of SRL activities, there is still some guidance on a conceptual level provided. However, this kind of creating PLEs is also the most demanding one. Learners have to plan the activities and then find appropriate widgets. This process still structures the creation and helps make aware how to use the PLE.

6.3. Template Store and Authoring

There are three operation modes possible which are specified in each template. First, in a template learning activities can be freely defined and associated with widgets directly. In this case no back-end infrastructure is needed and the template author has maximum freedom. Second, SRL entities are taken from the ontology. In this case the ontology service is questioned for the respective functionalities and the widget store returns the associated widget. Third, the categories of the widget store can be used as template entities, and then all widgets from the Widget Store are returned related to each category. In this way, the widget store is represented as a widget in the widget space.

In order to create a new template or to modify an existing template, a tool has been developed for this purpose (see Fig. 7). This tool displays the ontology as a graph and lets the user select single SRL entities in order to add them to a template.

A template can be constructed in three different ways. First there is an ontology available which connects learning strategies and learning techniques with functionalities of widgets. The learning strategies and techniques are used as template elements. By clicking on such an element, the associated widget functionalities are used to retrieve according widgets from the Widget Store. Second template type consists for learning activities that are freely defined and hard-wired with widgets. The third type consists of the tool categories of the Widget Store. In this last case the same widgets are displayed as in the Widget Store where the same tool categories are used, which actually implements the Widget Store as widget in the current space (Fig. 7).

7. Open System Architecture and Implementation

For the technical realisation of the approach described above a service-oriented design has been chosen that allows for integration with a widget container. The system architecture of the Mashup Recommender (see Fig. 8) consists of a front-end and several back-end services. The front-end or user interface is implemented as a widget to be included in an Open Social widget container. In this widget the learner selects SRL entities and gets other widgets recommended that can be included in the current widget space. SRL entities are organised in templates that bundle SRL entities. A template store holds different templates ensuring that different pedagogical approaches are implemented. An authoring tool allows for creating, modifying and deleting such templates in a Web-based environment. The back-end service is responsible for the recommendation logic. When the Mashup Recommender widget requests widgets for a learning activity, then the back-end service

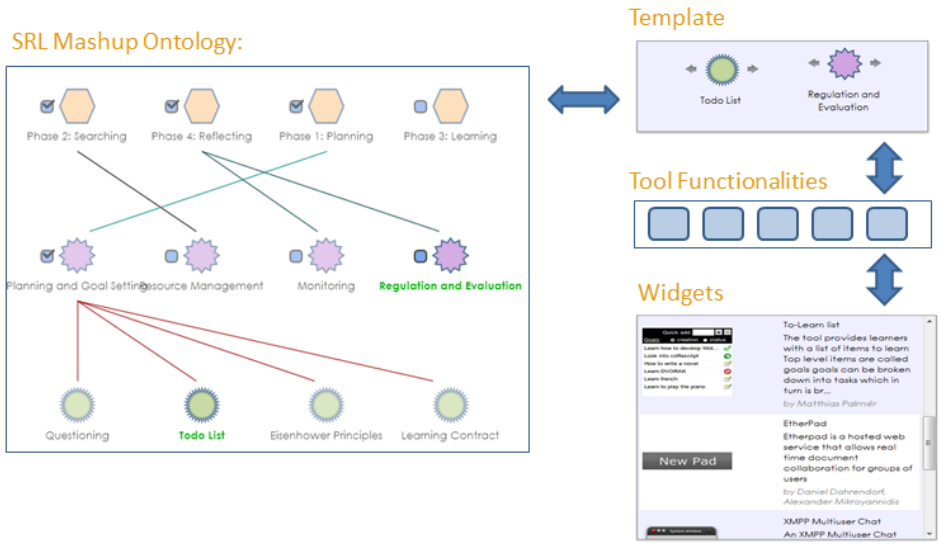

Fig. 7. Authoring Tool. This diagram schematically shows the authoring process. On the left side the ontology is displayed whose elements can be added to the template on the right side.

assembles such a list. Therefore it requests widget functionalities from the Ontology Service which translates learning activities to technical functionalities needed to perform the learning activity. Next step is to contact the Widget Store to get widgets that have assigned the respective functionalities. These widgets are returned back to the Mashup Recommender widget.

The ROLE Widget Store [13] is one of the basic components needed for the Mashup Recommender functionality. As described above it provides functionalities for searching widgets based on their metadata via the user interface. The same functionality is also available a REST interface which allows for search widgets according to one of the above mentioned vocabularies (widget categories, widget functionalities, domain concepts). This is the important feature for the Mashup Recommender, because it can search for widgets fitting to the ontology entities. More precisely, the Widget Store allows for searching its repository via SPARQL queries. Considering the fact that there are several metadata available for each widget, SPARQL search queries provide a very useful and flexible way of searching widgets.

In order to expose the ontology of learning strategies, learning techniques, and widget functionalities to other services, a Web service is used (Joseki) which makes available this RDF file using a SPARQL interface. In this way, other services can access the ontology with SPARQL queries and get the results in XML or JSON format. The same advantage of flexibility in formulating the search queries is provided for searching the ontology.

The Mashup Recommender back-end service is the access point for the related widget. If the Mashup Recommender widget searches for widgets for specific SRL entities, it queries the back-end service. The service then, queries the ontology service, in order to

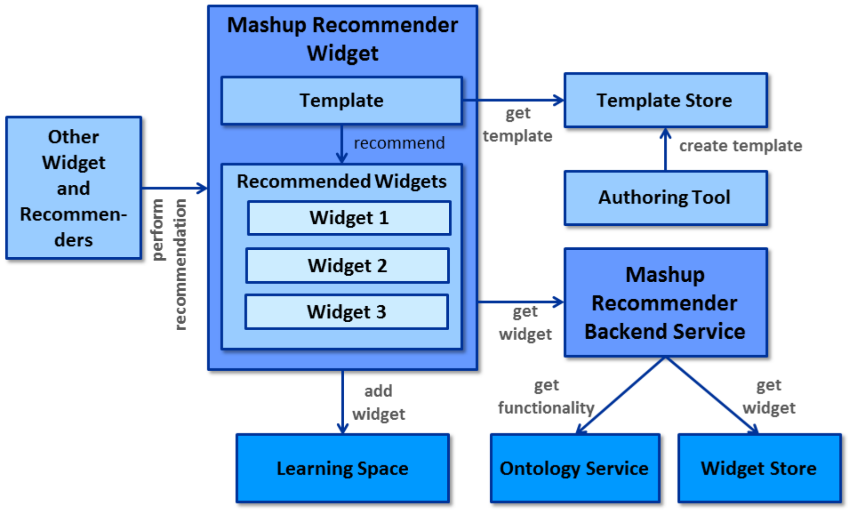

Fig. 8. Open System Architecture. This diagram shows the software components and how they are connected. The open architecture allows to be used fully or partially by other applications.

retrieve the related tool functionalities. Using these tool functionalities it asks the Widget Store for related widgets and gets a list of references and metadata of matching widgets. Using this information the service compiles a list of all retrieved widget references and metadata and sends it back to the Mashup Recommender widget.

The Mashup Recommender widget is the place where the user gets the recommendations and adds recommended widgets to the current widget space. Though implemented as Open Social Widget, it needs specific features of these containers that must provide an API to include new widgets. The ROLE platform provides a messaging mechanism to notify the container that a new widget should be integrated. The Mashup Recommender widget adds the selected widget accordingly.

The Mashup Recommender widget also provides an interface offering its service to other widgets. Since the basic concept of the ROLE platform is to freely combine widgets of all types, this openness has potential to combine recommender approaches. It has been tested with the Activity Recommender that guides the learner through the self-regulated learning process. Therefore it recommends learning activities to be performed. In order to add widget recommendations to these activity recommendations, the Activity Recommender sends the widget functionality to the Mashup Recommender which gives respective widget recommendations. In this way these two recommender widgets are combined to a more complex recommender system.

8. Evaluation

The Mash-Up Recommender was introduced and evaluated as part of two workshops where in sum 29 teachers and people from the educational sector participated. The first workshop was organised by the European project NEXT-TELL[13] and took place in Bad Waltersdorf, Austria, in December 2011. The participants consisted of 21 people including teachers and three people from the Austrian public administration. The teachers had medium until high interest in technology. The second workshop was organised as part of the AHA Konferenz[14] in Vienna, Austria, in April 2012. In this workshop 8 people participated, who had teaching and research experience.

Both workshops consisted of three parts: First, in an introduction session the Mashup Recommender's theoretical concept was explained and demonstrated. Second, in a hands-on-session the participants had to use the software and fulfil specific tasks. These tasks included the creation of templates for own purposes and the population of own templates and templates of others. Third, the approach of the Mashup Recommender was discussed and formal evaluation with a questionnaire was conducted.

Quantitative feedback using a questionnaire was provided by 13 participants. The answering format ranged from strongly disagree (1) to strongly agree (6) with higher values indicating stronger agreement. Fig. 9 shows a positive overall impression of the Mash-Up Recommender. The overall score was computed by the mean of the four individual items. Teachers reported the least agreement concerning creating their own template. However, the other items were evaluated more positively, which is the first indication of relevance and usefulness of this recommender approach.

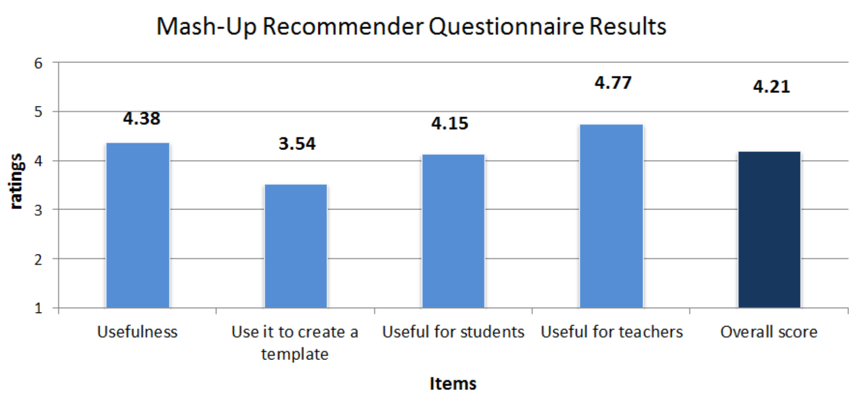

Fig. 9. Overall evaluation result of the Mashup Recommender.

Qualitative feedback was provided by all 29 participants, which gave more detailed insight. This kind of feedback was provided by the participants as free comments, discussion contributions, and spontaneous feedback while working with the Mashup Recommender. In general the participants understood the idea of the Mashup Recommender and reacted very positively to it. They saw its main advantage in the psycho-pedagogical underpinning regarding the SRL concept. In this way orientation for teachers and learners is provided to guide them through a large number of widgets, because a large number of

[13] http://www.next-tell.eu
[14] http://www.ahakonferenz.at/

available widgets might distract them from learning without any kind of guidance. Most of the teachers also highlighted that the Mashup Recommender covers meta-cognitive aspects of learning, which seems to be more important than ever, especially having life-long learning in mind.

Still some teachers raised concerns about the additional effort they have to invest in order to understand the Mashup Recommender functionality completely. They mentioned that this could be a barrier to get going with this new technology. That is why the teachers were in favour of getting tutorial material such as an online course or a specific workshop where concrete lessons could be planned using the Mash-Up Recommender.

9. Conclusion and Outlook

This article presented an approach how the creation and usage of Personal Learning Environments (PLE) can be supported. While in the past much effort has been done on the technological level of PLEs (as outlined in Section 2, there is still a lack of pedagogical support. Grounding on the theory of Self-regulated Learning (SRL) a model has been elaborated that is used for personal guidance. Technical implementation has been done in two ways. The Widget Store manages a repository of widgets and allows taggin them with SRL activities, categorisation, and domain-specific topics. The Mashup Recommender allows creating templates of SRL activities, that can be filled with appropriate widgets. A PLE created in this way is suitable for SRL, because it contains widgets that support SRL activities. Also the creation of a PLE is a SRL activity that is supported by the Widget Store and the Mashup Recommender.

Since all components have open interfaces, they can also be used by other widgets or services. For example, the Mashup Recommender back-end service can be queried to get widget recommendations for ontology entities, the Ontology service can be asked to get tool functionalities for certain entities, or the Mashup Recommender widget can be asked to retrieve widget recommendations for external (virtual) templates.

Widgets within a ROLE environment can interoperate. Therefore, other widgets can refer to recommendations of the mashup recommender and thus form an integrated environment. However, if widgets for all SRL phases are recommended and chosen by the user it might well that the widget space (the PLE) will appear overcrowded and therefore overtax the user. Layered PLEs like the PLMS prototype mentioned above might be promising approaches to avoiding this problem.

Great potential can be identified for further work based on the results presented in this paper. First of all, the approach of recommending widgets can be applied on other widget stores (for example those for smartphones). Possible further work could focus on the use of usage data by feeding back the information which widget in the PLE has actually been used. Specific hints can be given, if a widget already included in the widget space is not used. In this case it can be recommended to use this widget in a specific way (for the use with a certain learning strategy or technique). Additionally, the recommendation strategy can be improved by not only use ontology information, but also collaborative usage data by taking into account the information which widget has been selected for which SRL entity. Moreover, user preferences, goals, and knowledge levels can be taken into account. For example, widgets can be recommended that address the target knowledge of a learner.

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